

# VFO Variable Frequency Oscillator

In 1950's VFO was really a VFO  
Currently a VFO really a Digital Synthesized  
Oscillator

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## **G7C16**

**Which of the following is a typical application for a Direct Digital Synthesizer?**

- A. A high-stability variable frequency oscillator in a transceiver
- B. A digital voltmeter
- C. A digital mode interface between a computer and a transceiver
- D. A high-sensitivity radio direction finder

# RX Noise

Noise Blanker

- Blocks Rx on a Noise Pulse
- Typically Listens for the Noise  
on a Frequency Near Your  
Operating Frequency

Noise Reduction

- SDR
    - Plays with the bits
  - Analog Radio
    - Flat tops noise
  - If over used – Distorted audio
- 

## **G4A16**

**How does a noise blanker work?**

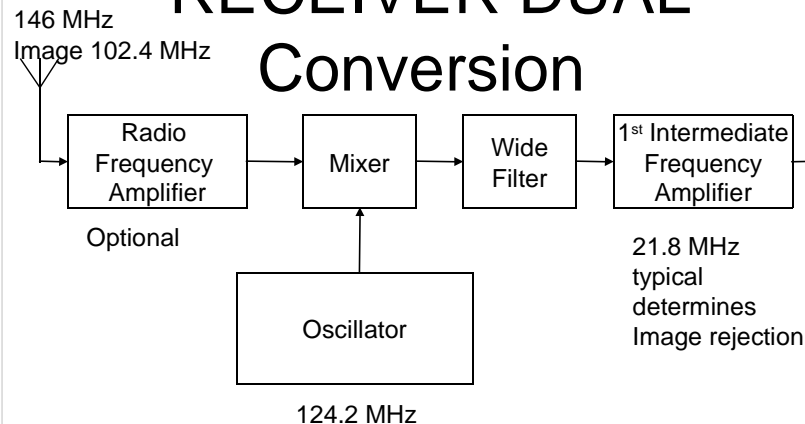
- A. By temporarily increasing received bandwidth
- B. By redirecting noise pulses into a filter capacitor
- C. By reducing receiver gain during a noise pulse
- D. By clipping noise peaks

**G4A17**

**What happens as the noise reduction control level in a receiver is increased?**

- A. Received signals may become distorted
- B. Received frequency may become unstable
- C. CW signals may become severely attenuated
- D. Received frequency may shift several kHz

# SUPERHETERODYNE RECEIVER DUAL Conversion



- Basic part of any receiver
- Front End of “Most” Receivers
- Just add
  - 2<sup>nd</sup> IF
  - Filters
  - Detector
  - Audio Stage

**G7C03**

**What circuit is used to process signals from the RF amplifier and local oscillator then send the result to the IF filter in a superheterodyne receiver?**

- A. Balanced modulator
- B. IF amplifier
- C. Mixer
- D. Detector

**G8B01**

**Which mixer input is varied or tuned to convert signals of different frequencies to an intermediate frequency (IF)?**

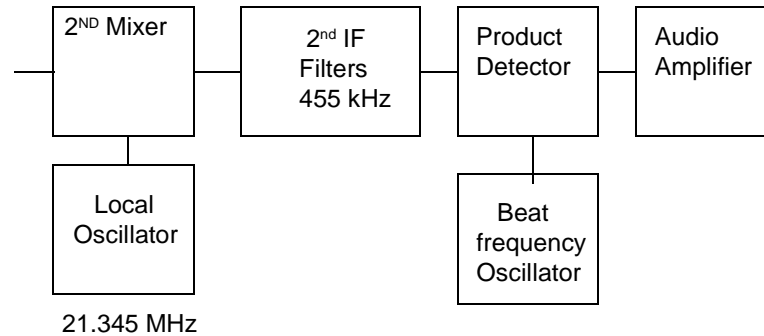
- A. Image frequency
- B. Local oscillator
- C. RF input
- D. Beat frequency oscillator

**G8B02**

**If a receiver mixes a 13.800 MHz VFO with a 14.255 MHz received signal to produce a 455 kHz intermediate frequency (IF) signal, what type of interference will a 13.345 MHz signal produce in the receiver?**

- A. Quadrature noise
- B. Image response
- C. Mixer interference
- D. Intermediate interference

## CW – SSB RECEIVER



- BFO inserts a signal to make a tone for CW
- BFO provides the carrier for SSB
- 2<sup>nd</sup> IF Filter determine the bandwidth of the receiver
- Bandwidth of Filter to Match Mode
  - Reduces signal to noise ratio

**G7C04**

**What circuit is used to combine signals from the IF amplifier and BFO and send the result to the AF amplifier in some single sideband receivers?**

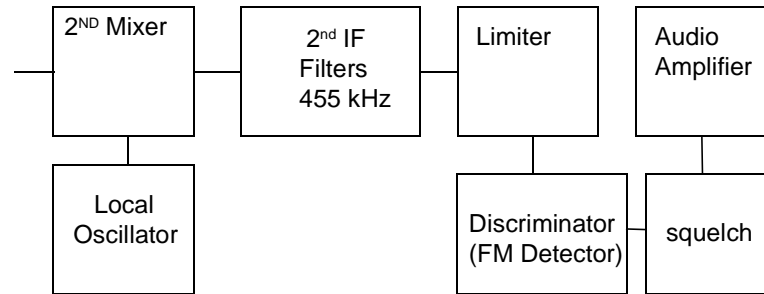
- A. RF oscillator
- B. IF filter
- C. Balanced modulator
- D. Product detector

**G8B09**

**Why is it good to match receiver bandwidth to the bandwidth of the operating mode?**

- A. It is required by FCC rules
- B. It minimizes power consumption in the receiver
- C. It improves impedance matching of the antenna
- D. It results in the best signal to noise ratio

## FM RECEIVER



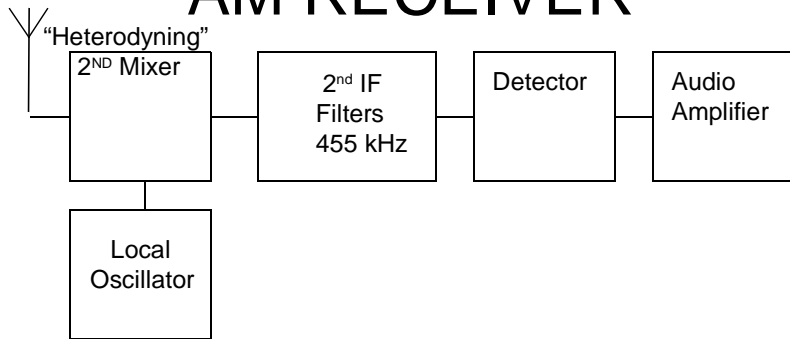
- Limiter removes any amplitude changes
  - Eliminates man made noise
- Discriminator converts frequency change to audio
- Squelch mutes noise

**G7C08**

**What type of circuit is used in many FM receivers to convert signals coming from the IF amplifier to audio?**

- A. Product detector
- B. Phase inverter
- C. Mixer
- D. Discriminator

## AM RECEIVER



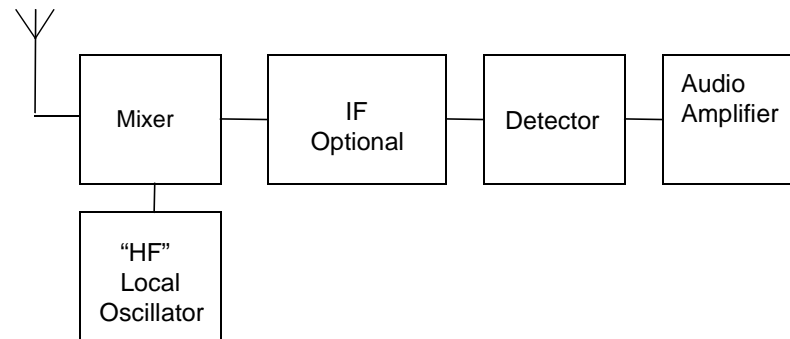
- Antique method like CW with none of the advantages
- Uses about 2X bandwidth of SSB
- Is susceptible to noise

### G8B03

**What is another term for the mixing of two RF signals?**

- A. Heterodyning
- B. Synthesizing
- C. Cancellation
- D. Phase inverting

## Simple Superheterodyne Receiver

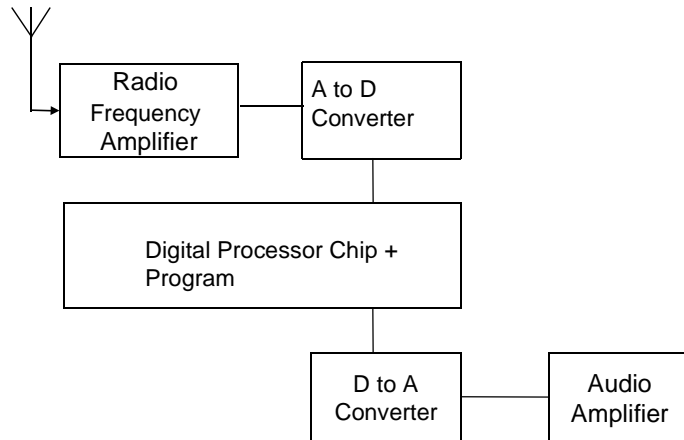


### G7C07

**What is the simplest combination of stages that implement a superheterodyne receiver?**

- A. RF amplifier, detector, audio amplifier
- B. RF amplifier, mixer, IF discriminator
- C. HF oscillator, mixer, detector
- D. HF oscillator, prescaler, audio amplifier

# Software Defined Radio



Can Use I and Q Demodulation

(This should not be General exam question)

(It is complex method and a complete lecture in engineering classes)

Phase Difference of I and Q is 90 Degrees

Can Generate and Decode all types of Modulation

## G7C09 (B)

**What is the phase difference between the I and Q signals that software-defined radio (SDR) equipment uses for modulation and demodulation?**

- A. Zero
- B. 90 degrees
- C. 180 degrees
- D. 45 degrees

## G7C10 (B)

**What is an advantage of using I and Q signals in software-defined radios (SDRs)?**

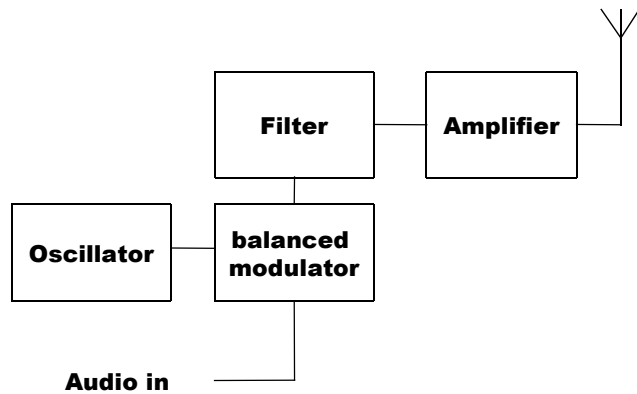
- A. The need for high resolution analog-to-digital converters is eliminated
- B. All types of modulation can be created with appropriate processing.
- C. Minimum detectable signal level is reduced
- D. Converting the signal from digital to analog creates mixing products

## G7C11

**What is meant by the term "software-defined radio" (SDR)?**

- A. A radio in which most major signal processing functions are performed by software
- B. A radio that provides computer interface for automatic logging of band and frequency
- C. A radio that uses crystal filters designed using software
- D. A computer model that can simulate performance of a radio to aid in the design process

# SSB TX



## G7C01

Which of the following is used to process signals from the balanced modulator then send them to the mixer in some single sideband phone transmitters?

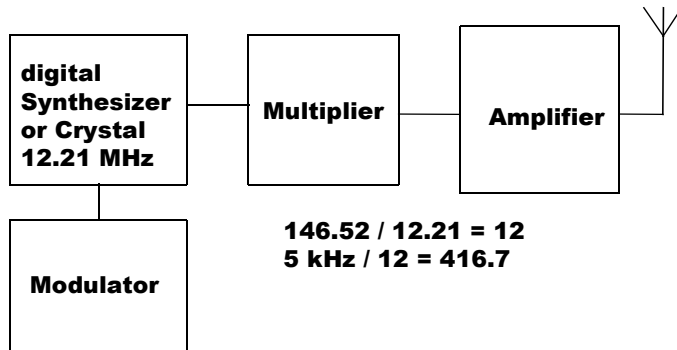
- A. Carrier oscillator
- B. Filter
- C. IF amplifier
- D. RF amplifier

## G7C02

Which circuit is used to combine signals from the carrier oscillator and speech amplifier then send the result to the filter in some single sideband phone transmitters?

- A. Discriminator
- B. Detector
- C. IF amplifier
- D. Balanced modulator

# FM TX



## G7C05

**Which of the following is an advantage of a direct digital synthesizer (DDS)?**

- A. Wide tuning range and no need for band switching
- B. Relatively high power output
- C. Relatively low power consumption
- D. Variable frequency with the stability of a crystal oscillator

## G8B07

**What is the frequency deviation for a 12.21 MHz reactance modulated oscillator in a 5 kHz deviation, 146.52 MHz FM phone transmitter?**

- A. 101.75 Hz
- B. 416.7 Hz
- C. 5 kHz
- D. 60 kHz

## G8B04

**What is the stage in a VHF FM transmitter that generates a harmonic of a lower frequency signal to reach the desired operating frequency?**

- A. Mixer
- B. Reactance modulator
- C. Pre-emphasis network
- D. Multiplier

**A Hidden Transmitter  
for Radio Direction  
Finding Practice  
is Always On.  
It may Get Hot!**

## G8B08

**Why is it important to know the duty cycle of the mode you are using when transmitting?**

- A. To aid in tuning your transmitter
- B. Some modes have high duty cycles which could exceed the transmitter's average power rating.
- C. To allow time for the other station to break in during a transmission
- D. All of these choices are correct



# CW Q Signals

What do all those Q - - mean

QRL – Frequency in use?

QRN – I am troubled by static

QRP – Low power

QRS - Send slower

QRV - Ready to receive message

QSK - Full break-in

QSL - Acknowledge receipt

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## G2C04

**What does the Q signal "QRL?" mean?**

- A. "Will you keep the frequency clear?"
- B. "Are you operating full break-in" or "Can you operate full break-in?"
- C. "Are you listening only for a specific station?"
- D. "Are you busy?", or "Is this frequency in use?"

## G2C10

**What does the Q signal "QRN" mean?**

- A. Send more slowly
- B. I am troubled by static
- C. Zero beat my signal
- D. Stop sending

## G2D10

**What is QRP operation?**

- A. Remote piloted model control
- B. Low power transmit operation
- C. Transmission using Quick Response Protocol
- D. Traffic relay procedure net operation

## G2C02

**What should you do if a CW station sends "QRS"?**

- A. Send slower
- B. Change frequency
- C. Increase your power
- D. Repeat everything twice

## G2C11

**What does the Q signal "QRV" mean?**

- A. You are sending too fast
- B. There is interference on the frequency
- C. I am quitting for the day
- D. I am ready to receive messages

## G2C01

**Which of the following describes full break-in telegraphy (QSK)?**

- A. Breaking stations send the Morse code prosign BK  
Automatic keyers are used to send Morse code instead of hand keys
- C. An operator must activate a manual send/receive switch before and after every transmission
- D. Transmitting stations can receive between code characters and elements

**G2C09**

**What does the Q signal "QSL" mean?**

- A. Send slower
- B. We have already confirmed by card
- C. I acknowledge receipt
- D. We have worked before

## More CW ... \_ ..\_ ..\_.

AR – End Formal message

RST with a C - Chirpy or unstable signal

CL – Closing Station

K - Go Ahead Send

KN – Listening only for a specific station

DX – Distant Station Outside the country

50.100 to 50.125 MHz

Reserved for DX (Band Plan)

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**G2C08**

**What prosign is sent to indicate the end of a formal message when using CW?**

- A. SK
- B. BK
- C. AR
- D. KN

**G2C07**

**When sending CW, what does a "C" mean when added to the RST report?**

- A. Chirpy or unstable signal
- B. Report was read from an S meter rather than estimated
- C. 100 percent copy
- D. Key clicks

**G2C03**

**What does it mean when a CW operator sends "KN" at the end of a transmission?**

- A. Listening for novice stations
- B. Operating full break-in
- C. Listening only for a specific station or stations
- D. Closing station now

**G2B08**

**What is the voluntary band plan restriction for U.S. station transmitting within the 48 contiguous states in the 50.1 to 50.125 MHz band segment?**

- A. Only contacts with stations not within the 48 contiguous states
- B. Only contacts with other stations within the 48 contiguous states
- C. Only digital contacts
- D. Only SSTV contacts

## More CW

Send no faster than you or the other station can receive

Zero Beat the station you want to "talk to"

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**G2C06**

**What does the term "zero beat" mean in CW operation?**

- A. Matching the speed of the transmitting station
- B. Operating split to avoid interference on frequency
- C. Sending without error
- D. Matching your transmit frequency to the frequency of a received signal

**G2C05**

**What is the best speed to use when answering a CQ in Morse code?**

- A. The fastest speed at which you are comfortable copying
- B. The speed at which the CQ was sent
- C. A slow speed until contact is established
- D. At the standard calling speed of 5 wpm

# Keying the TX

## Short Delay to Prevent TX from Damaging the RX

### Use anything you want

Manual key

Bug

Electronic key

Computer

Two wires

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#### G4A10

**What is the purpose of an electronic keyer?**

- A. Automatic transmit/receive switching
- B. Automatic generation of strings of dots and dashes for CW operation
- C. VOX operation
- D. Computer interface for PSK and RTTY operation

#### G4A09

Why is a time delay sometimes included in a transmitter keying circuit?

- A. To prevent stations from interfering with one another
- B. To allow the transmitter power regulators to charge properly
- C. To allow time for transmit-receive changeover operations to complete properly before RF output is allowed
- D. To allow time for a warning signal to be sent to other stations

# RTTY - Data

- RTTY Radio-Teletype
  - Baudot – 5 bit code
  - 170 Hz shift on HF
  - Audio frequency shift keying
    - Use LSB
- Data
  - 300 baud max below 28 MHz
  - 1200 baud max 10 meters
  - 19.6 Kilobaud on 6 – 2 meters
  - 20 kHz bandwidth 6 – 2 meters

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#### G1C07 [97.305(c), 97.307(f)(3)]

**What is the maximum symbol rate permitted for RTTY or data emission transmission on the 20-meter band?**

- A. 56 kilobaud
- B. 19.6 kilobaud
- C. 1200 baud
- D. 300 baud

**G1C08 [97.307(f)(3)]**

**What is the maximum symbol rate permitted for RTTY or data emission transmitted at frequencies below 28 MHz?**

- A. 56 kilobaud
- B. 19.6 kilobaud
- C. 1200 baud
- D. 300 baud

**G1C09 [97.305(c) and 97.307(f)(5)]**

**What is the maximum symbol rate permitted for RTTY or data emission transmitted on the 1.25-meter and 70-centimeter bands?**

- A. 56 kilobaud
- B. 19.6 kilobaud
- C. 1200 baud
- D. 300 baud

**G1C10 [97.305(c) and 97.307(f)(4)]**

**What is the maximum symbol rate permitted for RTTY or data emission transmissions on the 10-meter band?**

- A. 56 kilobaud
- B. 19.6 kilobaud
- C. 1200 baud
- D. 300 baud

**G1C11 [97.305(c) and 97.307(f)(5)]**

**What is the maximum symbol rate permitted for RTTY or data emission transmissions on the 2-meter band?**

- A. 56 kilobaud
- B. 19.6 kilobaud
- C. 1200 baud
- D. 300 baud

**G2E06**

**What is the most common frequency shift for RTTY emissions in the amateur HF bands?**

- A. 85 Hz
- B. 170 Hz
- C. 425 Hz
- D. 850 Hz

**G2E01**

**Which mode is normally used when sending an RTTY signal via AFSK with an SSB transmitter?**

- A. USB
- B. DSB
- C. CW
- D. LSB

# Frequencies for Data

- 80 Meters 3570 to 3600 kHz
- 20 Meters 14.070 to 14.100 MHz
- PSK31 Below RTTY 14.100 MHz

## G2E07

**What segment of the 80-meter band is most commonly used for digital transmissions?**

- A. 3570 - 3600 kHz
- B. 3500 - 3525 kHz
- C. 3700 - 3750 kHz
- D. 3775 - 3825 kHz

## G2E04

**What segment of the 20-meter band is most often used for digital transmissions?**

- A. 14.000 - 14.050 MHz
- B. 14.070 - 14.100 MHz
- C. 14.150 - 14.225 MHz
- D. 14.275 - 14.350 MHz

## G2E08

**In what segment of the 20-meter band are most PSK31 operations commonly found?**

- A. At the bottom of the slow-scan TV segment, near 14.230 MHz
- B. At the top of the SSB phone segment, near 14.325 MHz
- C. In the middle of the CW segment, near 14.100 MHz
- D. Below the RTTY segment, near 14.070 MHz

# Wi-Fi or Mesh Network

2.4 GHz

Using Modified Wi-Fi Gear

Shared with Home Wi-Fi Users

Some Channels are Ham Only

No Communication with Home Users  
allowed

10 Watt Max

Digital Communication (Cloud)

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## G1E08 [97.313(j)]

**When using modified commercial Wi-Fi equipment to construct an Amateur Radio Emergency Data Network (AREDN), what is the maximum allowed PEP transmitter output power?**

- A. 100 milliwatts
- B. 10 watts
- C. 100 watts
- D. 1500 watts

**G1E07 [97.111]**

**In what part of the 13-centimeter band may an amateur station communicate with non-licensed Wi-Fi stations?**

- A. Anywhere in the band
- B. Channels 1 through 4
- C. Channels 42 through 45
- D. No part

**G8C01**

**On what band do amateurs share channels with the unlicensed Wi-Fi service?**

- A. 432 MHz
- B. 902 MHz
- C. 2.4 GHz
- D. 10.7 GHz

## New Data Modes

Mode Must be Publicly Documented before it can be used

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**G1C13 [97.309(a)(4)]**

**What must be done before using a new digital protocol on the air?**

- A. Type-certify equipment to FCC standards
- B. Obtain an experimental license from the FCC
- C. Publicly document the technical characteristics of the protocol
- D. Submit a rule-making proposal to the FCC describing the codes and methods of the technique

# PSK31

- Variable bits per character
  - **Varicode**
- 31 is the approximate symbol rate
- Upper Case Letters generate Longer Characters
- BPSK31 Binary 2 Channels
- QPSK31 Quadrature 4 Channels
  - **Has Error Correction**
  - **Uses more bandwidth**

## G8C08

**Which of the following statements is true about PSK31?**

- A. Upper case letters make the signal stronger
- B. Upper case letters use longer Varicode signals and thus slow down transmission
- C. Varicode Error Correction is used to ensure accurate message reception
- D. Higher power is needed as compared to RTTY for similar error rates

## G8C09

**What does the number 31 represent in "PSK31"?**

- A. The approximate transmitted symbol rate
- B. The version of the PSK protocol
- C. The year in which PSK31 was invented
- D. The number of characters that can be represented by PSK31

## G8C12

**Which type of code is used for sending characters in a PSK31 signal?**

- A. Varicode
- B. Viterbi
- C. Volumetric
- D. Binary

## G8A06

**Which of the following is characteristic of QPSK31?**

- A. It is sideband sensitive
- B. It has forward error correction
- C. The bandwidth is slightly higher than BPSK31
- D. All these choices are correct



## Other Data Modes

- Packet – Old after RTTY
  - Data correction
  - Formatted Message
  - Header has address
- FT8 Mode of WSJT-X
  - Short Message 13 Characters
  - Grid locators, and Signal reports
  - One Second per Character
  - DX- Contesting
  - Needs Accurate computer clock
  - 8 Tone Frequency Shift Keying
  - Get Thru in Very Low Signal to Noise Ratios

### **G8C03**

**What part of a data packet contains the routing and handling information?**

- A. Directory
- B. Preamble
- C. Header
- D. Footer

### **G2E11**

**Which of the following is characteristic of the FT8 mode of the WSJT-X family?**

- A. It is a keyboard-to-keyboard chat mode
- B. Each transmission takes exactly 60 seconds
- C. It is limited to use on VHF
- D. Typical exchanges are limited to call signs, grid locators, and signal reports

### **G2E15**

**Which of the following is a requirement when using the FT8 digital mode?**

- A. A special hardware modem
- B. Computer time accurate within approximately 1 second
- C. Receiver attenuator set to -12 dB
- D. A vertically polarized antenna

### **G8A09**

**What type of modulation is used by the FT8 digital mode?**

- A. 8-tone frequency shift keying
- B. Vestigial sideband
- C. Amplitude compressed AM
- D. Direct sequence spread spectrum

**G8A12**

**Which of the following narrow-band digital modes can receive signals with very low signal-to-noise ratios?**

- A. MSK144
- B. FT8
- C. AMTOR
- D. MFSK32

## Poor Communication

- Very weak signal
- Noise
- Interference

**All can cause:**

- 1 Frequent retries or timeouts**
  - 2 Long pauses in message transmission**
  - 3 Failure to establish a connection between stations**
- 

**G2E03**

**What symptoms may result from other signals interfering with a PACTOR or WINMOR transmission?**

- A. Frequent retries or timeouts
- B. Long pauses in message transmission
- C. Failure to establish a connection between stations
- D. All of these choices are correct

# FCC Rules

- Automatic Control
    - Connect to the Internet
    - Called Automatically Controlled Digital
    - No operator
  - Automatic to Automatic
    - 1.25 Meters and above
    - 2 Meters & HF some Band segments
  - No Money
  - Third Party (Standard Rules)
- 

## **G1E03 [97.221]**

**What is required to conduct communications with a digital station operating under automatic control outside the automatic control band segments?**

- A. The station initiating the contact must be under local or remote control
- B. The interrogating transmission must be made by another automatically controlled station
- C. No third party traffic may be transmitted
- D. The control operator of the interrogating station must hold an Extra Class license

## **G1E09 [97.115]**

**Under what circumstances are messages that are sent via digital modes exempt from Part 97 third-party rules that apply to other modes of communication?**

- A. Under no circumstances
- B. When messages are encrypted
- C. When messages are not encrypted
- D. When under automatic control

# Pactor

- Speed Changes with Communication Quality
- If Quality Drops Too Far The Connection may Drop
- ACK NAK Retransmit on Errors
- Master Slave (Just 2)
- Can Be Monitored
- Characters 2 to 15 Bits
  - Most used Small (E)
  - Uncommon Large (Z)

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## G2E02

**How can a PACTOR modem or controller be used to determine if the channel is in use by other PACTOR stations?**

- A. Unplug the data connector temporarily and see if the channel-busy indication is turned off
- B. Put the modem or controller in a mode which allows monitoring communications without a connection
- C. Transmit UI packets several times and wait to see if there is a response from another PACTOR station
- D. Send the message: "Is this frequency in use?"

## G2E09

**How do you join a contact between two stations using the PACTOR protocol?**

- A. Send broadcast packets containing your call sign while in MONITOR mode
- B. Transmit a steady carrier until the PACTOR protocol times out and disconnects
- C. Joining an existing contact is not possible, PACTOR connections are limited to two stations
- D. Send a NAK response continuously so that the sending station has to pause

## G8C05

**In the PACTOR protocol, what is meant by an NAK response to a transmitted packet?**

- A. The receiver is requesting the packet be retransmitted
- B. The receiver is reporting the packet was received without error
- C. The receiver is busy decoding the packet
- D. The entire file has been received correctly

## G8C06

**What action results from a failure to exchange information due to excessive transmission attempts when using PACTOR or WINMOR?**

- A. The checksum overflows
- B. The connection is dropped
- C. Packets will be routed incorrectly
- D. Encoding reverts to the default character set

## JT65 and JT9

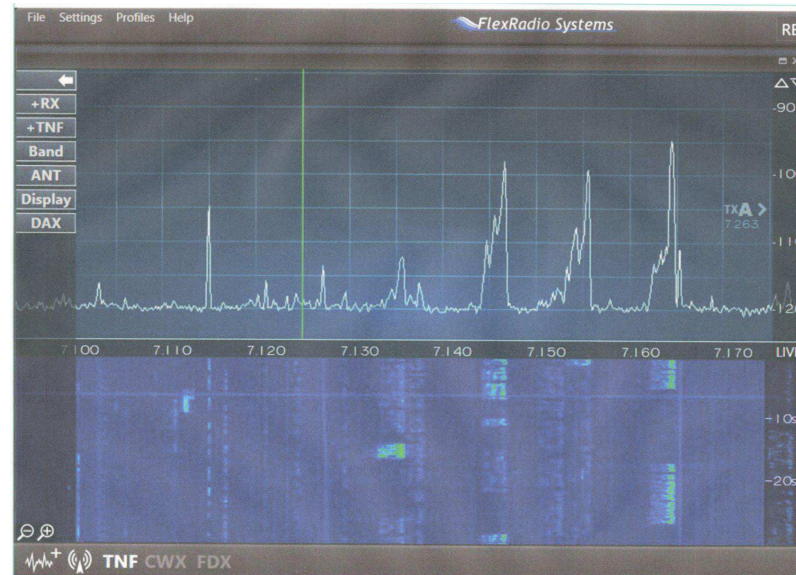
- Slow baud rate
- Weak signal
- Multi Tone Signal (AFSK)
- Uses USB

**G2E05**

**What is the standard sideband used to generate a JT65 or JT9 digital signal when using AFSK in any amateur band?**

- A. LSB
- B. USB
- C. DSB
- D. SSB

## Spectrum Analyzer Waterfall Display



**Slide Complements Don AI6RE**

**G8C14**

**Which of the following describes a waterfall display?**

- A. Frequency is horizontal, signal strength is vertical, time is intensity
- B. Frequency is vertical, signal strength is intensity, time is horizontal
- C. Frequency is horizontal, signal strength is intensity, time is vertical
- D. Frequency is vertical, signal strength is horizontal, time is intensity

**G8C13**

**What is indicated on a waterfall display by one or more vertical lines on either side of a digital signal?**

- A. Long path propagation
- B. Backscatter propagation
- C. Insufficient modulation
- D. Overmodulation

## Winlink

- Internet Connection
- Send a Connect message on Frequency

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**G2E13**

**Which communication system sometimes uses the Internet to transfer messages?**

- A. Winlink
- B. RTTY
- C. ARES
- D. Skywarn

**G2E10**

**Which of the following is a way to establish contact with a digital messaging system gateway station?**

- A. Send an email to the system control operator
- B. Send QRL in Morse code
- C. Respond when the station broadcasts its SSID
- D. Transmit a connect message on the station's published frequency

# FSK - AFSK

- FSK Frequency Shift Keying
  - Change TX frequency
- AFSK Audio FSK
  - Tones into Radio Input
  - One Tone for Mark
  - A different Tone for Space
- Mark – Space
  - Old Terms for On – OFF
  - Mark = On
  - Space = Off

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## G8C11

**How are the two separate frequencies of a Frequency Shift Keyed (FSK) signal identified?**

- A. Dot and Dash
- B. On and Off
- C. High and Low
- D. Mark and Space

## G8A01

**How is an FSK signal generated?**

- A. By keying an FM transmitter with a sub-audible tone
- B. By changing an oscillator's frequency directly with a digital control signal
- C. By using a transceiver's computer data interface protocol to change frequencies
- D. By reconfiguring the CW keying input to act as a tone generator

# Codes

- Baudot
  - Old 5 Bit Code used on First TTY
  - 5 bits only 32 possible Characters
  - Letters – Figures Shift
- ASCII
  - 8 Bit Code including Parity
    - Parity Error Checking

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## G8C04

**Which of the following describes Baudot code?**

- A. A 7-bit code with start, stop and parity bits
- B. A code using error detection and correction
- C. A 5-bit code with additional start and stop bits
- D. A code using SELCAL and LISTEN

# Thing Go Wrong

- ALC Automatic Level Control
  - Not Set properly
    - Distorts the signal
    - Can cause spurious emissions
- Baud Rate Mismatch
  - You Get Junk
- Mark – Space Reversed
  - You Get Junk
- Wrong Side Band
  - You Get Junk
- RF Signal Gets into Audio
  - VOX Does Not Unkey
  - Distorted signal
  - Bad communication (Time-outs)
- Packet Containing Errors
  - Requests the Packet be Retransmitted
  - Forward Error Correction
    - Transmitting redundant information



**G2E14**

**What could be wrong if you cannot decode an RTTY or other FSK signal even though it is apparently tuned in properly?**

- A. The mark and space frequencies may be reversed
- B. You may have selected the wrong baud rate
- C. You may be listening on the wrong sideband
- D. All of these choices are correct

**G4A14**

**What is likely to happen if a transceiver's ALC system is not set properly when transmitting AFSK signals with the radio using single sideband mode?**

- A. ALC will invert the modulation of the AFSK mode
- B. Improper action of ALC distorts the signal and can cause spurious emissions
- C. When using digital modes, too much ALC activity can cause the transmitter to overheat
- D. All of these choices are correct

**G4A15**

**Which of the following can be a symptom of transmitted RF being picked up by an audio cable carrying AFSK data signals between a computer and a transceiver?**

- A. The VOX circuit does not un-key the transmitter
- B. The transmitter signal is distorted
- C. Frequent connection timeouts
- D. All of these choices are correct

**G8C07**

**How does the receiving station respond to an ARQ data mode packet containing errors?**

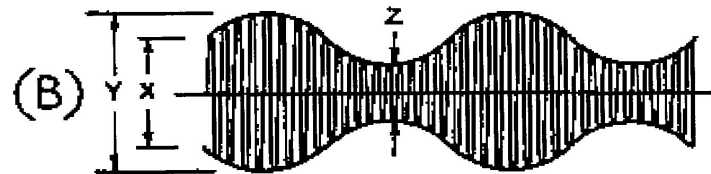
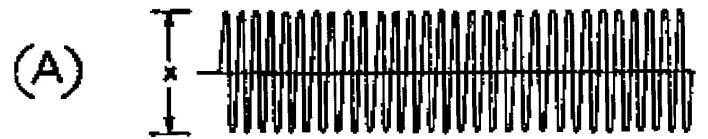
- A. It terminates the contact
- B. It requests the packet be retransmitted
- C. It sends the packet back to the transmitting station
- D. It requests a change in transmitting protocol

**G8C10**

**How does forward error correction (FEC) allow the receiver to correct errors in received data packets?**

- A. By controlling transmitter output power for optimum signal strength
- B. By using the varicode character set
- C. By transmitting redundant information with the data
- D. By using a parity bit with each character

## AM



**Modulation Envelope**

### G8A05

**What type of modulation varies the instantaneous power level of the RF signal?**

- A. Frequency shift keying
- B. Phase modulation
- C. Frequency modulation
- D. Amplitude modulation

### G8A11

**What is the modulation envelope of an AM signal?**

- A. The waveform created by connecting the peak values of the modulated signal
- B. The carrier frequency that contains the signal
- C. Spurious signals that envelop nearby frequencies
- D. The bandwidth of the modulated signal

# Single Sideband

Similar to AM

But only one sideband

With the Carrier Suppressed

Puts more power where it counts

Difficult to tune in

Sounds like Donald Duck

# FM

Frequency Modulation

Phase Modulation

Uses a Reactance Modulator

Changes phase angle

Both produce FM

---

## G8A03

**What is the name of the process that changes the instantaneous frequency of an RF wave to convey information?**

- A. Frequency convolution
- B. Frequency transformation
- C. Frequency conversion
- D. Frequency modulation

## G8A04

**What emission is produced by a reactance modulator connected to a transmitter RF amplifier stage?**

- A. Multiplex modulation
- B. Phase modulation
- C. Amplitude modulation
- D. Pulse modulation

**G8A02**

**What is the name of the process that changes the phase angle of an RF wave to convey information?**

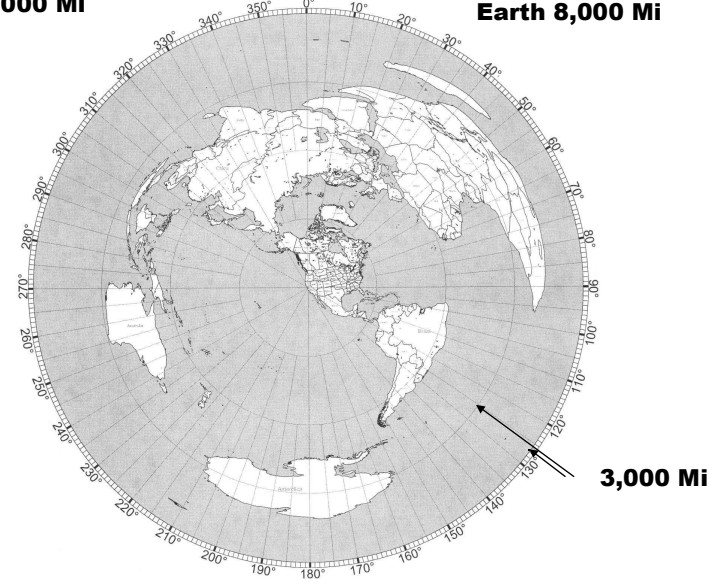
- A. Phase convolution**
- B. Phase modulation**
- C. Angle convolution**
- D. Radian inversion**

**Azimuthal Map**

**Circumference  
= 25,000 Mi**

Center: 37°40'31"N 121°45'15"W  
Courtesy of Tom (NS6T)

**Diameter of the  
Earth 8,000 Mi**



**G2D04**

**Which of the following describes an azimuthal projection map?**

- A. A map that shows accurate land masses**
- B. A map that shows true bearings and distances from a particular location**
- C. A map that shows the angle at which an amateur satellite crosses the equator**
- D. A map that shows the number of degrees longitude that an amateur satellite appears to move westward at the equator with each orbit**

# SUN

- Solar Flares
- Coronal Mass Ejections
  - Charged Particals
  - Spews Solar Plasma
    - 20 to 40 Hour to Affect Earth
  - Can Cause
    - Geomagnetic Disturbances (Storm)
      - Degrades HF Above or Below 45 Degrees
      - Aurora increase – Reflects VHF
    - Sudden Ionospheric Disturbances (D layer)
      - Raises the LUF
- Measurement
  - Sun Spot Number
    - Count of Sun Spots (Higher Better)
  - A Index
    - Long Term Magnetic Stability
  - K Index
    - Short Term Magnetic Stability
  - Solar Flux Index
    - Signal Strength at 10.7 cm or 28 GHz

## G3A09

**What benefit can high geomagnetic activity have on radio communications?**

- A. Auroras that can reflect VHF signals
- B. Higher signal strength for HF signals passing through the polar regions
- C. Improved HF long path propagation
- D. Reduced long delayed echoes

## G3A01

**What is the significance of the sunspot number with regard to HF propagation?**

- A. Higher sunspot numbers generally indicate a greater probability of good propagation at higher frequencies
- B. Lower sunspot numbers generally indicate greater probability of sporadic E propagation
- C. A zero sunspot number indicate radio propagation is not possible on any band
- D. All of these choices are correct.

## G3A05

**What is the solar flux index?**

- A. A measure of the highest frequency that is useful for ionospheric propagation between two points on the Earth
- B. A count of sunspots which is adjusted for solar emissions
- C. Another name for the American sunspot number
- D. A measure of solar radiation at 10.7 centimeters wavelength

## G3A12

**What does the K-index indicate?**

- A. The relative position of sunspots on the surface of the Sun
- B. The short term stability of the Earth's magnetic field
- C. The stability of the Sun's magnetic field
- D. The solar radio flux at Boulder, Colorado

**G3A09**

**What effect does a high sunspot number have on radio communications?**

- A. High-frequency radio signals become weak and distorted
- B. Frequencies above 300 MHz become usable for long-distance communication
- C. Long-distance communication in the upper HF and lower VHF range is enhanced
- D. Microwave communications become unstable

**G3A06**

**What is a geomagnetic storm?**

- A. A sudden drop in the solar flux index
- B. A thunderstorm which affects radio propagation
- C. Ripples in the ionosphere
- D. A temporary disturbance in the Earth's magnetosphere

**G3A08**

**Which of the following effects can a geomagnetic storm have on radio propagation?**

- A. Improved high-latitude HF propagation
- B. Degraded high-latitude HF propagation
- C. Improved ground-wave propagation
- D. Improved chances of UHF ducting

**G3A13**

**What does the A-index indicate?**

- A. The relative position of sunspots on the surface of the Sun
- B. The amount of polarization of the Sun's electric field
- C. The long term stability of the Earth's geomagnetic field
- D. The solar radio flux at Boulder, Colorado

**G3A11**

**How long does it take charged particles from coronal mass ejections to affect radio propagation on the Earth?**

- A. 28 days
- B. 14 days
- C. 4 to 8 minutes
- D. 20 to 40 hours

**G3A14**

**How are radio communications usually affected by the charged particles that reach the Earth from solar coronal holes?**

- A. HF communications are improved
- B. HF communications are disturbed
- C. VHF/UHF ducting is improved
- D. VHF/UHF ducting is disturbed

**G3A13**

**What does the A-index indicate?**

- A. The relative position of sunspots on the surface of the sun
- B. The amount of polarization of the sun's electric field
- C. The long-term stability of Earth's geomagnetic field
- D. The solar radio flux at Boulder, Colorado

# More SUN

- Summer Time Noise
    - On Lower HF
  - Sun's rotation on its axis
    - 28 day cycle
    - Changes HF propagation
- 

## G2D11

**Which of the following is typical of the lower HF frequencies during the summer?**

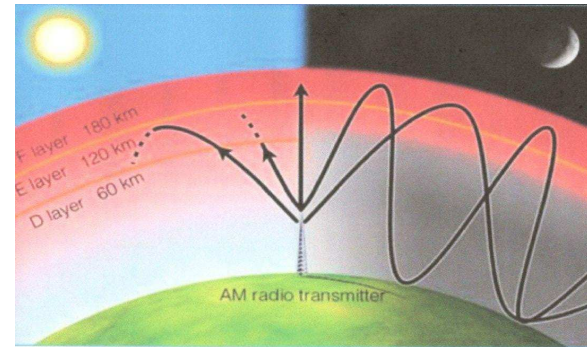
- A. Poor propagation at any time of day
- B. World-wide propagation during the daylight hours
- C. Heavy distortion on signals due to photon absorption
- D. High levels of atmospheric noise or "static"

## G3A10

**What causes HF propagation conditions to vary periodically in a roughly 28-day cycle?**

- A. Long term oscillations in the upper atmosphere
- B. Cyclic variation in Earth's radiation belts
- C. The sun's rotation on its axis
- D. The position of the moon in its orbit

# IONIZATION



F layer becomes 2 Layers in the Day Time

Upper F<sub>2</sub> LAYER Longest Hop

Lower F<sub>1</sub> LAYER

---

## G3C01

**Which ionospheric layer is closest to the surface of the Earth?**

- A. The D layer
- B. The E layer
- C. The F1 layer
- D. The F2 layer

**G3C03**

**Why is the F2 region mainly responsible for the longest distance radio wave propagation?**

- A. Because it is the densest ionospheric layer
- B. Because it does not absorb radio waves as much as other ionospheric regions
- C. Because it is the highest ionospheric region
- D. All of these choices are correct

**G3C02**

**Where on the Earth do ionospheric layers reach their maximum height?**

- A. Where the Sun is overhead
- B. Where the Sun is on the opposite side of the Earth
- C. Where the Sun is rising
- D. Where the Sun has just set

# IONOSPHERE

- **Caused by**
  - Solar radiation
  - Ultraviolet
    - 8 Min from Sun to Earth
  - Sunspots
    - Higher the Better
      - Raises the MUF (10-15 Meters work)
      - 20 Meters and up Work Always
    - 11 year cycle
    - Max 2013-2014
- **Bends radio waves**
- **Max at midday Summer**
- **Min just before dawn**
- **D region**
  - Bad guy Absorbs radio waves
- **F region**
  - Good guy Reflects radio waves



**G3A03**

**Approximately how long does it take the increased ultraviolet and X-ray radiation from solar flares to affect radio propagation on the Earth?**

- A. 28 days
- B. 1 to 2 hours
- C. 8 minutes
- D. 20 to 40 hours

**G3A04**

**Which of the following are least reliable for long distance communications during periods of low solar activity?**

- A. 80 meters and 160 meters
- B. 60 meters and 40 meters
- C. 30 meters and 20 meters
- D. 15 meters, 12 meters and 10 meters

**G3A07**

**At what point in the solar cycle does the 20-meter band usually support worldwide propagation during daylight hours?**

- A. At the summer solstice
- B. Only at the maximum point of the solar cycle
- C. Only at the minimum point of the solar cycle
- D. At any point in the solar cycle

**G3C05**

**Why is long distance communication on the 40-meter, 60-meter, 80-meter and 160-meter bands more difficult during the day?**

- A. The F layer absorbs signals at these frequencies during daylight hours
- B. The F layer is unstable during daylight hours
- C. The D layer absorbs signals at these frequencies during daylight hours
- D. The E layer is unstable during daylight hours

**G3C11**

**Which ionospheric layer is the most absorbent of long skip signals during daylight hours on frequencies below 10 MHz?**

- A. The F2 layer
- B. The F1 layer
- C. The E layer
- D. The D layer

# Sudden Ionospheric Disturbance or Geomagnetic Storm

- It disrupts signals on lower frequencies more than those on higher frequencies
  - Disturbance in the Earth's magnetosphere
- 

## **G3A02**

**What effect does a Sudden Ionospheric Disturbance have on the daytime ionospheric propagation of HF radio waves?**

- A. It enhances propagation on all HF frequencies
- B. It disrupts signals on lower frequencies more than those on higher frequencies
- C. It disrupts communications via satellite more than direct communications
- D. None, because only areas on the night side of the Earth are affected

## **G3A06**

**What is a geomagnetic storm?**

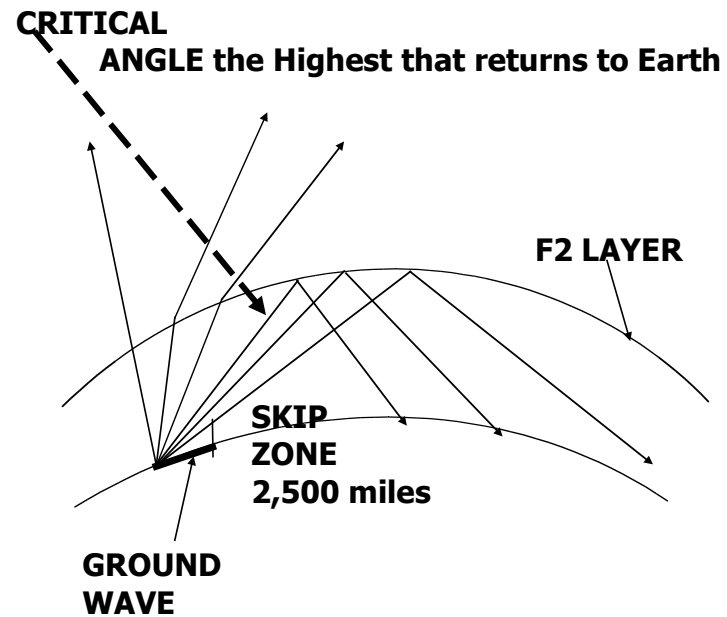
- A. A sudden drop in the solar flux index
- B. A thunderstorm that affects radio propagation
- C. Ripples in the ionosphere
- D. A temporary disturbance in Earth's magnetosphere

## **G3A08 (B)**

**Which of the following effects can a geomagnetic storm have on radio propagation?**

- A. Improved high-latitude HF propagation
- B. Degraded high-latitude HF propagation
- C. Improved ground wave propagation
- D. Degraded ground wave propagation

# SKIP ZONE



## G3B09

**What is the approximate maximum distance along the Earth's surface that is normally covered in one hop using the F2 region?**

- A. 180 miles
- B. 1,200 miles
- C. 2,500 miles
- D. 12,000 miles

## G3C04

**What does the term "critical angle" mean as used in radio wave propagation?**

- A. The long path azimuth of a distant station
- B. The short path azimuth of a distant station
- C. The lowest takeoff angle that will return a radio wave to the Earth under specific ionospheric conditions
- D. The highest takeoff angle that will return a radio wave to the Earth under specific ionospheric conditions

# Scatter

- Not a nice reflector (Low Return)
- Weak signals (Power Scattered)
- Wavering sound (multi path)
- Gets into skip zone
- Gets thru above MUF

---

## G3C09

**What type of propagation allows signals to be heard in the transmitting station's skip zone?**

- A. Faraday rotation
- B. Scatter
- C. Chordal hop
- D. Short-path

## G3C06

**What is a characteristic of HF scatter signals?**

- A. They have high intelligibility
- B. They have a wavering sound
- C. They have very large swings in signal strength
- D. All of these choices are correct

## G3C07

**What makes HF scatter signals often sound distorted?**

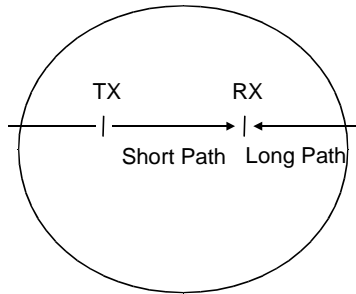
- A. The ionospheric layer involved is unstable
- B. Ground waves are absorbing much of the signal
- C. The E-region is not present
- D. Energy is scattered into the skip zone through several different radio wave paths

## G3C08

**Why are HF scatter signals in the skip zone usually weak?**

- A. Only a small part of the signal energy is scattered into the skip zone
- B. Signals are scattered from the magnetosphere which is not a good reflector
- C. Propagation is through ground waves which absorb most of the signal energy
- D. Propagation is through ducts in F region which absorb most of the energy

# Short – Long Path



- Short path beam pointed E
- Long path beam pointed W
  - Transmission time Longer

## G3B01

**How might a sky-wave signal sound if it arrives at your location by both short path and long path propagation?**

- A. Periodic fading approximately every 10 seconds
- B. Signal strength increased by 3 dB
- C. The signal might be cancelled causing severe attenuation
- D. A well-defined echo might be heard

## G2D06

**How is a directional antenna pointed when making a "long-path" contact with another station?**

- A. Toward the rising Sun
- B. Along the gray line
- C. 180 degrees from its short-path heading
- D. Toward the north

# PROPAGATION

- **Ground-wave**
  - Short range
- **Sky-wave**
  - Bounces off ionosphere
  - Multi-hop bounces multiple times
  - Long range
- **Skip zone**
  - No signal (Scatter Only)
  - Between ground wave and first bounce
- **Scatter**
  - E layer (1 Hop = 1,200 miles)
- **Max usable frequency (MUF)**
  - Highest frequency to return to earth
  - Best frequency just below MUF
  - Changes with ionization
- **Lowest usable frequency (LUF)**
  - Absorbed by the D Layer

## G3B03

**Which of the following applies when selecting a frequency for lowest attenuation when transmitting on HF?**

- A. Select a frequency just below the MUF
- B. Select a frequency just above the LUF
- C. Select a frequency just below the critical frequency
- D. Select a frequency just above the critical frequency

## G3B05

**What usually happens to radio waves with frequencies below the MUF and above the LUF when they are sent into the ionosphere?**

- A. They are bent back to the Earth
- B. They pass through the ionosphere
- C. They are amplified by interaction with the ionosphere
- D. They are bent and trapped in the ionosphere to circle the Earth

## G3B06

**What usually happens to radio waves with frequencies below the LUF?**

- A. They are bent back to the Earth
- B. They pass through the ionosphere
- C. They are completely absorbed by the ionosphere
- D. They are bent and trapped in the ionosphere to circle the Earth

## G3B07

**What does LUF stand for?**

- A. The Lowest Usable Frequency for communications between two points
- B. The Longest Universal Function for communications between two points
- C. The Lowest Usable Frequency during a 24 hour period
- D. The Longest Universal Function during a 24 hour period

**G3B11**

**What happens to HF propagation when the LUF exceeds the MUF?**

- A. No HF radio frequency will support ordinary sky-wave communications over the path
- B. HF communications over the path are enhanced
- C. Double hop propagation along the path is more common
- D. Propagation over the path on all HF frequencies is enhanced

**G3B02**

**What factor or factors affect the MUF?**

- A. Path distance and location
- B. Time of day and season
- C. Solar radiation and ionospheric disturbances
- D. All of these choices are correct

**G3B10**

**What is the approximate maximum distance along the Earth's surface that is normally covered in one hop using the E region?**

- A. 180 miles
- B. 1,200 miles
- C. 2,500 miles
- D. 12,000 miles

**G3B08**

**What does MUF stand for?**

- A. The Minimum Usable Frequency for communications between two points
- B. The Maximum Usable Frequency for communications between two points
- C. The Minimum Usable Frequency during a 24 hour period
- D. The Maximum Usable Frequency during a 24 hour period

## Beacon Stations

- Propagation Signal
- 100 Watt Max
- 1 Transmitter per Location per Frequency
- Automatic control 28.2 to 28.3 MHz
- Hearing the Signal Means You Can Communicate
- 14.1, 18.11, 21.15, 24.93, and 28.2 MHz are Beacon Frequencies
- Listen for W W V Colorado or  
W W V H Hawaii  
on 2.5, 5, 10, 15, 20, 25 MHZ

**G3B04**

**What is a reliable way to determine if the MUF is high enough to support skip propagation between your station and a distant location on frequencies between 14 and 30 MHz?**

- A. Listen for signals from an international beacon in the frequency range you plan to use
- B. Send a series of dots on the band and listen for echoes from your signal
- C. Check the strength of TV signals from Western Europe
- D. Check the strength of signals in the MF AM broadcast band

**G1E10 [97.101]**

**Why should an amateur operator normally avoid transmitting on 14.100, 18.110, 21.150, 24.930 and 28.200 MHz?**

- A. A system of propagation beacon stations operates on those frequencies
- B. A system of automatic digital stations operates on those frequencies
- C. These frequencies are set aside for emergency operations
- D. These frequencies are set aside for bulletins from the FCC

**G1B02 [97.203(b)]**

**With which of the following conditions must beacon stations comply?**

- A. A beacon station may not use automatic control
- B. The frequency must be coordinated with the National Beacon Organization
- C. The frequency must be posted on the Internet or published in a national periodical
- D. There must be no more than one beacon signal transmitting in the same band from the same station location

**G1B03 [97.3(a)(9)]**

**Which of the following is a purpose of a beacon station as identified in the FCC rules?**

- A. Observation of propagation and reception
- B. Automatic identification of repeaters
- C. Transmission of bulletins of general interest to Amateur Radio licensees
- D. Identifying net frequencies

**G1B10 [97.203(c)]**

**What is the power limit for beacon stations?**

- A. 10 watts PEP output
- B. 20 watts PEP output
- C. 100 watts PEP output
- D. 200 watts PEP output

**G1B09 [97.203(d)]**

**On what HF frequencies are automatically controlled beacons permitted?**

- A. On any frequency if power is less than 1 watt
- B. On any frequency if transmissions are in Morse code
- C. 21.08 MHz to 21.09 MHz
- D. 28.20 MHz to 28.30 MHz



# WSPR

## Weak Signal Propagation Reporter

4FSK

Viterbi Variable bit Characters

50 Bits Call, Grid Locator, Power

110 Second Message

Needs an Accurate Clock

Forward Error Correction

SN Ratio -28 dB

---

### G8C02

**Which digital mode is used as a low-power beacon for assessing HF propagation?**

- A. WSPR
- B. Olivia
- C. PSK31
- D. SSB-SC

## VHF-UHF PROPAGATION

- **Line of sight**
- **Reflections**
- **Ducting**
  - Tropospheric bounce
  - Drops off with increasing frequency
  - Zero to 11 miles up
  - Temperature inversion
    - High-pressure system
  - 2 meters
- **Sky-wave**
  - Happens in good times
  - 6 and 2 meters
  - E region
  - Sporadic E
  - Short hop on 10 meters as an indicator

# RF Interference

- Audio devices
  - Diodes make receivers
    - Oxidation counts too
  - Bypass Caps Short-Out RF
  - Ferrite Beads to Absorb RF
  - SSB - Sounds distorted
  - CW - Clicks or Clicks & Hum
- Radio
  - Broadband noise
    - Spark gap TX
    - Arcing
  - Diodes Make Mixers too
    - Oxidation counts too
  - Intermodulation
    - Mixing of two signals

## G4C01

**Which of the following might be useful in reducing RF interference to audio frequency devices?**

- A. Bypass inductor
- B. Bypass capacitor
- C. Forward-biased diode
- D. Reverse-biased diode

## G4C02

**Which of the following could be a cause of interference covering a wide range of frequencies?**

- A. Not using a balun or line isolator to feed balanced antennas
- B. Lack of rectification of the transmitter's signal in power conductors
- C. Arcing at a poor electrical connection
- D. Using a balun to feed an unbalanced antenna

## G4C03

**What sound is heard from an audio device or telephone if there is interference from a nearby single sideband phone transmitter?**

- A. A steady hum whenever the transmitter is on the air
- B. On-and-off humming or clicking
- C. Distorted speech
- D. Clearly audible speech

## G4C04

**What is the effect on an audio device when there is interference from a nearby CW transmitter?**

- A. On-and-off humming or clicking
- B. A CW signal at a nearly pure audio frequency
- C. A chirpy CW signal
- D. Severely distorted audio

**G8B12**

**What process combines two signals in a non-linear circuit or connection to produce unwanted spurious outputs?**

- A. Intermodulation
- B. Heterodyning
- C. Detection
- D. Rolloff

## TVI

- Television interference
- Check your TV first
- Harmonics
  - Channels depend on operating frequency
- Filters
  - High pass
    - On TV
    - Cuts HF frequencies
  - Low pass
    - On transmitter
    - Reduces harmonics
- Band reject
  - Passes all but a small band
  - Keep 2 meters out of a TV
- Cable TV
  - Can interfere with ham radio

# FILTERS

- **Low pass**
  - Passes frequencies below filter cut-off
    - Use on your transmitter
    - Reduces harmonic radiation
- **High pass**
  - Passes frequencies above filter cut-off
    - Use between antenna and TV set
    - **Not** needed on cable
- **Notch**
  - Removes a small piece of spectrum
- **Band pass**
  - Pass a small piece of spectrum
    - Used in receivers to tune the station you want
    - Rejects all frequencies except a small band
    - Upper and lower half-power points
- **All Filters have Insertion Loss**

## G7C12

**What is the frequency above which a low-pass filter's output power is less than half the input power?**

- A. Notch frequency
- B. Neper frequency
- C. Cutoff frequency
- D. Rolloff frequency

## G7C13

**What term specifies a filter's maximum ability to reject signals outside its passband?**

- A. Notch depth
- B. Rolloff
- C. Insertion loss
- D. Ultimate rejection

## G7C14

**The bandwidth of a band-pass filter is measured between what two frequencies?**

- A. Upper and lower half-power
- B. Cutoff and rolloff
- C. Pole and zero
- D. Image and harmonic

## G7C15

**What term specifies a filter's attenuation inside its passband?**

- A. Insertion loss
- B. Return loss
- C. Q
- D. Ultimate rejection

# Interference Not Your Fault

- Telephone
  - Poorly designed phones may receive radio signals
  - Line filters may help
    - Do not install it for anyone
- Receiver Overload
  - Poorly designed radios-TVs
  - Fundamental overload
- Part 15 devices
  - May cause interference

# Ground Loop

- Current in the Loop Produce Voltage
  - Make All Ground Connections to a Single Point (No Loop)
  - Single Point Grounding All Equipment in the Shack Will Minimize RF “Hot Spots”
- 

## **G4C09**

### **How can a ground loop be avoided?**

- A. Connect all ground conductors in series
- B. Connect the AC neutral conductor to the ground wire
- C. Avoid using lock washers and star washers when making ground connections
- D. Connect all ground conductors to a single point

## **G4C10**

### **What could be a symptom of a ground loop somewhere in your station?**

- A. You receive reports of "hum" on your station's transmitted signal
- B. The SWR reading for one or more antennas is suddenly very high
- C. An item of station equipment starts to draw excessive amounts of current
- D. You receive reports of harmonic interference from your station

**G4C11**

**What technique helps to minimize RF "hot spots" in an amateur station?**

- A. Building all equipment in a metal enclosure
- B. Using surge suppressor power outlets
- C. Bonding all equipment enclosures together
- D. Low-pass filters on all feed lines

## Audio Cable - RF

- RF can induce Current into Audio Cables
  - Place Clamp-on ferrite choke on Cable
- 

**G4C08**

**Which of the following would reduce RF interference caused by common-mode current on an audio cable?**

- A. Placing a ferrite choke around the cable
- B. Adding series capacitors to the conductors
- C. Adding shunt inductors to the conductors
- D. Adding an additional insulating jacket to the cable

## RFI from Your Car

- Charging System
  - Alternator Whine
- Fuel System
  - Pump Motor
- On Board Computers
  - Lots of them

---

### G4E07

**Which of the following may cause receive interference in a radio installed in a vehicle?**

- A. The battery charging system
- B. The fuel delivery system
- C. The vehicle control computer
- D. All of these choices are correct

## RF SAFETY

- RF CAN BURN
  - It feels like a burn not a shock
  - Keep antennas away from people
  - Antenna high and out of reach
- RF CAN HEAT
  - Microwave oven!
  - Heating is frequency dependent
  - You do **not** need to touch the antenna or feedline to heat the body
  - Very dangerous to eyes
    - *Cataracts*

---

### G0A01

**What is one way that RF energy can affect human body tissue?**

- A. It heats body tissue
- B. It causes radiation poisoning
- C. It causes the blood count to reach a dangerously low level
- D. It cools body tissue

# LIMITS SET?

- MAXIMUM PERMITTED EXPOSURE (MPE)
  - How much heat should the body be exposed to?
    - Whole-body specific absorption rate (sar)
  - Controlled by
    - Frequency
    - Distance from antenna
    - Power of the transmitter
    - Gain of the antenna
    - Time the transmitter is on
    - Type of modulation

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## G0A02

**Which of the following properties is important in estimating whether an RF signal exceeds the maximum permissible exposure (MPE)?**

- A. Its duty cycle
- B. Its frequency
- C. Its power density
- D. All of these choices are correct

## G0A07

**What effect does transmitter duty cycle have when evaluating RF exposure?**

- A. A lower transmitter duty cycle permits greater short-term exposure levels
- B. A higher transmitter duty cycle permits greater short-term exposure levels
- C. Low duty cycle transmitters are exempt from RF exposure evaluation requirements
- D. High duty cycle transmitters are exempt from RF exposure requirements



## DEFINITIONS

- CONTROLLED SPACE
  - You and your family
  - 6 minute averaging
- UNCONTROLLED SPACE
  - Your neighbors
  - No control of exposure
  - 30 minute averaging
- NONIONIZING RADIATION
  - Electromagnetic
  - Radio
  - Below ultraviolet
  - Heats the body

---

### G0A04

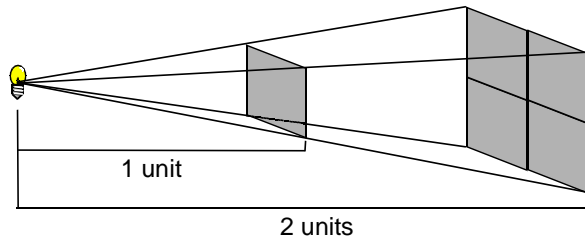
**What does "time averaging" mean in reference to RF radiation exposure?**

- A. The average amount of power developed by the transmitter over a specific 24 hour period
- B. The average time it takes RF radiation to have any long-term effect on the body
- C. The total time of the exposure
- D. The total RF exposure averaged over a certain time

## MEASUREMENT UNITS

- ELECTRIC FIELD
  - VOLTS per METER (V/m)
- MAGNETIC FIELD
  - AMPERES per METER (A/m)
- POWER DENSITY
  - MILLIWATTS per CENTIMETER<sup>2</sup> (mW/cm<sup>2</sup>)
- MAKING MEASUREMENTS?
  - You can't!
  - Instruments are expensive
  - Reading affected by
    - The probe
    - People
    - Ground interaction
    - Other wires ---

## POWER VS. DISTANCE



## EXPOSURE POWER

- Inversely proportional to the distance squared
- Directly proportional to:
  - Transmitter power
  - Transmitter duty cycle
  - Antenna gain
  - Modulation Type
    - FM = Always on
    - CW = Only when keyed
    - SSB = Lowest

## MPE the FCC & YOU

- FCC specifies exposure limits
  - Specified in Part 97 & Part 1
  - You can
    - Measure the exposure
    - Calculate with computer programs
    - Calculate based on FCC Part 1 & Office of Engineering and Technology Bulletin No. 65
  - Re-evaluate for any change of equipment
  - You have to indicate your understanding of the exposure limits on your 610 form
  - No records are required **-BUT**

**G0A03 [97.13(c)(1)]**

**How can you determine that your station complies with FCC RF exposure regulations?**

- A. By calculation based on FCC OET Bulletin 65
- B. By calculation based on computer modeling
- C. By measurement of field strength using calibrated equipment
- D. All of these choices are correct

**G0A08**

**Which of the following steps must an amateur operator take to ensure compliance with RF safety regulations when transmitter power exceeds levels specified in FCC Part 97.13?**

- A. Post a copy of FCC Part 97.13 in the station
- B. Post a copy of OET Bulletin 65 in the station
- C. Perform a routine RF exposure evaluation
- D. All of these choices are correct

**G0A09**

**What type of instrument can be used to accurately measure an RF field?**

- A. A receiver with an S meter
- B. A calibrated field strength meter with a calibrated antenna
- C. An SWR meter with a peak-reading function
- D. An oscilloscope with a high-stability crystal marker generator

## What If? You Exceed MPE

- Move Antenna
  - Reduce Power
  - Reduce Time On the Air
  - All To Reduce Human Exposure
- 

**G0A05**

**What must you do if an evaluation of your station shows RF energy radiated from your station exceeds permissible limits?**

- A. Take action to prevent human exposure to the excessive RF fields
- B. File an Environmental Impact Statement (EIS-97) with the FCC
- C. Secure written permission from your neighbors to operate above the controlled MPE limits
- D. All of these choices are correct

**G0A10**

**What is one thing that can be done if evaluation shows that a neighbor might receive more than the allowable limit of RF exposure from the main lobe of a directional antenna?**

- A. Change to a non-polarized antenna with higher gain
- B. Post a warning sign that is clearly visible to the neighbor
- C. Use an antenna with a higher front-to-back ratio
- D. Take precautions to ensure that the antenna cannot be pointed in their direction

**G0A11**

**What precaution should you take if you install an indoor transmitting antenna?**

- A. Locate the antenna close to your operating position to minimize feed line radiation
- B. Position the antenna along the edge of a wall to reduce parasitic radiation
- C. Make sure that MPE limits are not exceeded in occupied areas
- D. Make sure the antenna is properly shielded

## COMMON SENSE and RF EXPOSURE

- Keep antennas high & out of reach
- Keep people away from antennas
- Keep hand-held radio antennas away from your head & others
- Mount your mobile antenna on the roof of the car (rubber duck antennas don't work well in cars)
- Keep all shields in place
- Use coax not open line
- Use minimum power
- Turn off the transmitter before working on your antenna
- Keep exposure levels below limits

# WHY, WHAT and EXCEPTIONS

- Why
  - So you won't cook your neighbors or your family
- What
  - Radio frequency 3 kHz to 300 GHz
  - Limits on 300 kHz to 100 GHz
  - Limits hardest 30 MHz to 300 MHz
    - body most sensitive
- Exception
  - Transmitters below 50 Watts (PEP)
  - 40 Meters and below 500 Watts

## **G0A01**

**What is one way that RF energy can affect human body tissue?**

- A. It heats body tissue
- B. It causes radiation poisoning
- C. It causes the blood count to reach a dangerously low level
- D. It cools body tissue

# Tower

Max height

200 ft

Less near airport (FAA)

FCC – FAA registration for more

Climbing

Turn off everything on the tower

Safety belt

Point D ring hooks away  
from tower

In working order

Bond grounds

Use bolts or clamps

Solder can melt from lightning

## G0B07

**Which of these choices should be observed when climbing a tower using a safety belt or harness?**

- A. Never lean back and rely on the belt alone to support your weight
- B. Confirm that the belt is rated for the weight of the climber and that it is within its allowable service life
- C. Ensure that all heavy tools are securely fastened to the belt D-ring
- D. All of these choices are correct

## G0B08

**What should be done by any person preparing to climb a tower that supports electrically powered devices?**

- A. Notify the electric company that a person will be working on the tower
- B. Make sure all circuits that supply power to the tower are locked out and tagged
- C. Unground the base of the tower
- D. All of these choices are correct

## G4C07

**Why should soldered joints not be used with the wires that connect the base of a tower to a system of ground rods?**

- A. The resistance of solder is too high
- B. Solder flux will prevent a low conductivity connection
- C. Solder has too high a dielectric constant to provide adequate lightning protection
- D. A soldered joint will likely be destroyed by the heat of a lightning strike

**G0B11**

**Which of the following is good practice for lightning protection grounds?**

- A. They must be bonded to all buried water and gas lines
- B. Bends in ground wires must be made as close as possible to a right angle
- C. Lightning grounds must be connected to all ungrounded wiring
- D. They must be bonded together with all other grounds

**G1B01 [97.15(a)]**

**What is the maximum height above ground to which an antenna structure may be erected without requiring notification to the FAA and registration with the FCC, provided it is not at or near a public use airport?**

- A. 50 feet
- B. 100 feet
- C. 200 feet
- D. 300 feet

**G0B14**

**What precaution should you take whenever you adjust or repair an antenna?**

- A. Ensure that you and the antenna structure are grounded
- B. Turn off the transmitter and disconnect the feed line
- C. Wear a radiation badge
- D. All these choices are correct

## Tower Basics

### Installation

Stay away from Power wires

10 Ft Space in any Direction

Check height limit near Airport

Guy wires per manufacturers instructions

Use Stainless steel hardware

Ground each leg to a Ground rod.

Bond everything

### Climbing

Safety belt – Safety Glasses

Get a Helper

Check for Damage

Check Guy wires

Not in a Lightning storm

# MECHANICAL SAFETY

## Safety equipment

Safety belt  
Hard hat  
Safety glasses

## Power lines

## Tower Climbing

### Get someone to help you

*Make sure they have a hard  
hat and safety glasses*

### Be sure the tower is in good shape

### Get everything you need before climbing

### Check tower guy wires

Frayed wires  
Loose cables  
Loose turnbuckles  
Loose anchors  
Rusty cable

Climb **crank**-up towers only when Down

# STATION SAFETY

## Ground all equipment

Water pipe (plastic)  
8' copper clad ground rod

## AC power

National electrical code

12 gage good for 20 Amps

14 gage good for 15 Amps

Fuse the hot side

Do not over fuse

## Ground-fault

Color code

Black = hot  
White = neutral  
Green or copper =  
safety ground

AC plug

Brass screw = hot  
Silver screw = neutral  
Green screw = safety  
ground



**G0B01**

**Which wire or wires in a four-conductor connection should be attached to fuses or circuit breakers in a device operated from a 240 VAC single phase source?**

- A. Only the two wires carrying voltage
- B. Only the neutral wire
- C. Only the ground wire
- D. All wires

**G0B02**

**According to the National Electrical Code, what is the minimum wire size that may be used safely for wiring with a 20 ampere circuit breaker?**

- A. AWG number 20
- B. AWG number 16
- C. AWG number 12
- D. AWG number 8

**G0B03**

**Which size of fuse or circuit breaker would be appropriate to use with a circuit that uses AWG number 14 wiring?**

- A. 100 amperes
- B. 60 amperes
- C. 30 amperes
- D. 15 amperes

**G4C13**

**Why must the metal enclosure of every item of station equipment be grounded?**

- A. It prevents a blown fuse in the event of an internal short circuit
- B. It prevents signal overload
- C. It ensures that the neutral wire is grounded
- D. It ensures that hazardous voltages cannot appear on the chassis

Lightning

Disconnect & Ground Antennas

Unplug Equipment

Bond all grounds

No sharp turns (very high frequency)

## Ground

Rod in the Ground

Should be one point

Ground loop

National Electrical Code

Electrical safety

RF

SHORT run of wire

Avoid resonant length

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### G0B06

**Which of the following is covered by the National Electrical Code?**

- A. Acceptable bandwidth limits
- B. Acceptable modulation limits
- C. Electrical safety inside the ham shack
- D. RF exposure limits of the human body

## AC Power

Use ground fault interrupters

Check the current going out & the current coming back

They should be the same

If not the GFI turns off

Gas Generator

Produce carbon monoxide

Use gasoline

Fill only when off

Do not back feed PG&E

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### G0B04

**Which of the following is a primary reason for not placing a gasoline-fueled generator inside an occupied area?**

- A. Danger of carbon monoxide poisoning
- B. Danger of engine over torque
- C. Lack of oxygen for adequate combustion
- D. Lack of nitrogen for adequate combustion

**G0B05**

**Which of the following conditions will cause a Ground Fault Circuit Interrupter (GFCI) to disconnect the 120 or 240 Volt AC line power to a device?**

- A. Current flowing from one or more of the voltage-carrying wires to the neutral wire**
  - B. Current flowing from one or more of the voltage-carrying wires directly to ground**
  - C. Overvoltage on the voltage-carrying wires**
  - D. All of these choices are correct**
- (Bad answer)*

**G0B13**

**What must you do when powering your house from an emergency generator?**

- A. Disconnect the incoming utility power feed**
- B. Insure that the generator is not grounded**
- C. Insure that all lightning grounds are disconnected**
- D. All of these choices are correct**

**G0B09**

**Which of the following is true of an emergency generator installation?**

- A. The generator should be located in a well-ventilated area**
- B. The generator must be insulated from ground**
- C. Fuel should be stored near the generator for rapid refueling in case of an emergency**
- D. All these choices are correct**

# ELECTRICAL SAFETY

**Know how to turn off the power!**

Install a disconnect switch

**CPR**

Remove the power

Get help

CPR

**Current**

1/500 of an Amp painful

1/10 of an Amp can be fatal

Heart stops

Disrupts the electrical functions of cells

Causes involuntary muscle contractions

No rings, bracelets

**Voltage**

30 volts dangerous

No loose jewelry

**Capacitors hold a charge for a long time**

Short them out after the power is off

**Fuse**

Protects Circuit and You

Use the correct rating

## Miscellaneous

### Interlocks

Keep you from killing yourself  
Turn off power when door or  
cabinet is opened

### Lead

It's bad for you  
It's in solder

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#### G0B10

**Which of the following is a danger from lead-tin solder?**

- A. Lead can contaminate food if hands are not washed carefully after handling the solder
- B. High voltages can cause lead-tin solder to disintegrate suddenly
- C. Tin in the solder can "cold flow" causing shorts in the circuit
- D. RF energy can convert the lead into a poisonous gas

#### G0B12

**What is the purpose of a power supply interlock?**

- A. To prevent unauthorized changes to the circuit that would void the manufacturer's warranty
- B. To shut down the unit if it becomes too hot
- C. To ensure that dangerous voltages are removed if the cabinet is opened
- D. To shut off the power supply if too much voltage is produced

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119

## POWER SUPPLIES

12 VDC (13.8 V)

New Radios

Great for mobile

Noise filter

"Power supply" 117VAC

Regulated to 13.8 Volts

Radios Don't Like Over  
Voltage

Use under size power  
supply + a gel-cell  
battery

Cost less

Works when the power fails

Transmitting draws a lot of  
power

Receiving draws minimal  
power

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120

## WHY COAX?

It is shielded

**No radiation**

**Can be run next to metal**

It can be run under ground

Few Special Installation Requirements

Cut off any excess

**Length = loss**

**Loss increases with frequency**

If coax gets hot replace it

Most Coax is Black – UV

Failure from Moisture or UV

Transmitting Coax is 50 Ohm

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### G9A02

**What are the typical characteristic impedances of coaxial cables used for antenna feed lines at amateur stations?**

- A. 25 and 30 ohms
- B. 50 and 75 ohms
- C. 80 and 100 ohms
- D. 500 and 750 ohms

## COAX

- **RG 58**

- 50 ohm 3dB loss per 100 ft @ 100 MHz

- **RG 59**

- 72 ohm 3dB loss per 100 ft @ 100 MHz

- **RG 8**

- 50 ohm 2.5dB loss per 100 ft @ 100 MHz

- **RG 213**

- 50 ohm 2.5 dB loss per 100 ft @ 100 MHz

- **RG 174**

- 50 ohm 11 dB loss per 100 ft @ 100 MHz

- **9913**

- 50 ohm 1.3 dB loss per 100 ft @ 100 MHz
- Air core = water pipe

- **Heliax**

- 50 ohm .2 dB loss per 100 ft @ 100 MHz

- **Hard line**

- Pipe inside pipe
- Extremely low loss

**G9A05**

**How does the attenuation of coaxial cable change as the frequency of the signal it is carrying increases?**

- A. Attenuation is independent of frequency
- B. Attenuation increases
- C. Attenuation decreases
- D. Attenuation reaches a maximum at approximately 18 MHz

**G9A06**

**In what units is RF feed line loss usually expressed?**

- A. Ohms per 1000 feet
- B. Decibels per 1000 feet
- C. Ohms per 100 feet
- D. Decibels per 100 feet

## **OPEN LINE**

- **Balanced**

- 300 Ohms and up
- Impedance Controlled By**
  - Diameter of Conductors**
  - Space Between Conductors**

- **Low loss**

- Can be effected by weather

- **Must be isolated from other conductors**

- **May require an impedance match**

- Balun to match standard 50 ohm unbalanced coax
- Located at the antenna

- **Can radiate a signal**

**G9A01**

**Which of the following factors determine the characteristic impedance of a parallel conductor antenna feed line?**

- A. The distance between the centers of the conductors and the radius of the conductors
- B. The distance between the centers of the conductors and the length of the line
- C. The radius of the conductors and the frequency of the signal
- D. The frequency of the signal and the length of the line

**G9A03**

**What is the typical characteristic impedance of "window line" parallel transmission line?**

- A. 50 ohms
- B. 75 ohms
- C. 100 ohms
- D. 450 ohms

# SWR

## Standing Wave Ratio

### SWR

A ratio of the forward power to the antenna to the reflected power returned from the antenna

### Power Meter

Forward - reflected = actual

### SWR Meter

Measures SWR directly

Do not use a HF SWR meter at VHF

### Readings

1 to 1 Best You Can Get

**50 Ohm to 50 Ohm**

2 to 1 Ok

**Most Modern TX start to Reduce power over 2 to 1**

Erratic Readings

**Something is Loose or Not making good Contact**

**G9A04**

**What might cause reflected power at the point where a feed line connects to an antenna?**

- A. Operating an antenna at its resonant frequency
- B. Using more transmitter power than the antenna can handle
- C. A difference between feed line impedance and antenna feed point impedance
- D. Feeding the antenna with unbalanced feed line

**G9A07**

**What must be done to prevent standing waves on an antenna feed line?**

- A. The antenna feed point must be at DC ground potential
- B. The feed line must be cut to a length equal to an odd number of electrical quarter wavelengths
- C. The feed line must be cut to a length equal to an even number of physical half wavelengths
- D. The antenna feed point impedance must be matched to the characteristic impedance of the feed line

**G9A08**

**If the SWR on an antenna feed line is 5 to 1, and a matching network at the transmitter end of the feed line is adjusted to 1 to 1 SWR, what is the resulting SWR on the feed line?**

- A. 1 to 1
- B. 5 to 1
- C. Between 1 to 1 and 5 to 1 depending on the characteristic impedance of the line
- D. Between 1 to 1 and 5 to 1 depending on the reflected power at the transmitter

**G9A09**

**What standing wave ratio will result when connecting a 50 ohm feed line to a non-reactive load having 200 ohm impedance?**

- A. 4:1
- B. 1:4
- C. 2:1
- D. 1:2

**G9A10**

**What standing wave ratio will result when connecting a 50 ohm feed line to a non-reactive load having 10 ohm impedance?**

- A. 2:1
- B. 50:1
- C. 1:5
- D. 5:1

**G9A11**

**What standing wave ratio will result when connecting a 50 ohm feed line to a non-reactive load having 50 ohm impedance?**

- A. 2:1
- B. 1:1
- C. 50:50
- D. 0:0



**G9A12**

**What is the interaction between high standing wave ratio (SWR) and transmission line loss?**

- A. There is no interaction between transmission line loss and SWR
- B. If a transmission line is lossy, high SWR will increase the loss
- C. High SWR makes it difficult to measure transmission line loss
- D. High SWR reduces the relative effect of transmission line loss

**G9A13**

**What is the effect of transmission line loss on SWR measured at the input to the line?**

- A. The higher the transmission line loss, the more the SWR will read artificially low
- B. The higher the transmission line loss, the more the SWR will read artificially high
- C. The higher the transmission line loss, the more accurate the SWR measurement will be
- D. Transmission line loss does not affect the SWR measurement

**G4B10**

**Which of the following can be determined with a directional wattmeter?**

- A. Standing wave ratio
- B. Antenna front-to-back ratio
- C. RF interference
- D. Radio wave propagation

**G4B11**

**Which of the following must be connected to an antenna analyzer when it is being used for SWR measurements?**

- A. Receiver
- B. Transmitter
- C. Antenna and feed line
- D. All of these choices are correct

**G4B12**

**What problem can occur when making measurements on an antenna system with an antenna analyzer?**

- A. Permanent damage to the analyzer may occur if it is operated into a high SWR
- B. Strong signals from nearby transmitters can affect the accuracy of measurements
- C. The analyzer can be damaged if measurements outside the ham bands are attempted
- D. Connecting the analyzer to an antenna can cause it to absorb harmonics

# Connectors

## UHF – PL259

Up to 150 MHz (BAD)

seal against water if  
outside

## N

Up to 10 GHz

seal against water if  
outside

## SMA

Small Threaded GHz

## DB 9

Computer

Newer Radios

## USB

Computer

## RCA - Phono

Audio

## Keyed Connectors

Prevent incorrect mating

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### G2E12

**Which of the following connectors would be a good choice for a serial data port?**

- A. PL-259
- B. Type N
- C. Type SMA
- D. DE-9 How about DB-9

### G6B13

**Which of these connector types is commonly used for RF connections at frequencies up to 150 MHz?**

- A. Octal
- B. RJ-11
- C. PL-259
- D. DB-25

### G6B12

**Which of these connector types is commonly used for audio signals in Amateur Radio stations?**

- A. PL-259
- B. BNC
- C. RCA Phono
- D. Type N

### G6B11

**What is a type SMA connector?**

- A. A large bayonet connector usable at power levels more than 1 KW
- B. A small threaded connector suitable for signals up to several GHz
- C. A connector designed for serial multiple access signals
- D. A type of push-on connector intended for high-voltage applications

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**G6B07**

**Which of the following describes a type N connector?**

- A. A moisture-resistant RF connector useful to 10 GHz**
- B. A small bayonet connector used for data circuits
- C. A threaded connector used for hydraulic systems
- D. An audio connector used in surround-sound installations